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SPATIAL GEOMETRY OF THE HUMAN PELVIS

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16. Abstract

This report presents a three-dimensional description of adult female and male pelves from the Hamann-Todd skeletal collection, Cleveland Museum of Natural History. Based on a linear height/weight matching strategy and the 1961-1964 U.S. Health and Examination Survey (HES) data, specimens were selected to represent the small female, medium male, and large male pelvic sizes. One hundred and twenty-three anatomically defined points are used to describe the spatial pelvic geometry in a pelvic-anatomical axis system. A statistical summary of means and standard deviations is presented as X, Y, and Z coordinate value sets to identify each point in three-dimensional space. Full-scale models for each size category were produced for design modeling of anthropomorphic test devices. These data will also be useful as comparative standards for forensic investigations of air crashes and quantitative information on size and shape variability of adult human pelves.

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SPATIAL GEOMETRY OF THE HUMAN PELVIS

INTRODUCTION

As a part of the human skeletal system, the pelvis is located at approximately the center of the body and forms a structure through which forces are transmitted. Under impact conditions, vertical forces are transmitted from the seat through the ischial tuberosities, and horizontal forces are transmitted from the seatbelt through the ilium. When crash tests are conducted using anthropomorphic test devices to represent the human body, submarining of the test device occasionally occurs and has been attributed to the interaction of the test device pelvis geometry and the seat restraint system (5). Thus, the geometry of the adult human pelvis is an important parameter in the dynamic behavior of the human body. The pelvis has also been used to determine sex of skeletal remains among disaster victims (4). Differences in those dimensions which affect size and shape of the pelvic inlet and outlet (i.e., the birth canal) are used in this identification process. In addition, the obstetrical significance of the size and shape of the female pelvis has long been noted and categorized.

EXPERIMENTAL DESIGN

The features described for these various applications in the geometry of human skeletal anatomy have not been described in a systematic manner that would provide representative models of the complete human pelvis. As a result, an investigation has been conducted to measure the three-dimensional size and shape of the adult male and female pelves. Specimens for this investigation were obtained from the Hamann-Todd (H-T) skeletal collection in the Cleveland Museum of Natural History. The specimens were selected from nearly 3000 human skeletons of documented age, sex, and race. The skeletons came from the dissection room population of Western Reserve School of Medicine between 1919 and 1939. A complete series of anthropometric dimensions were obtained by Dr. Todd and his associates prior to the skeletonization of these cadavers. These data were used to select the specimens so that they represented as closely as possible the current general U.S. noninstitutionalized population. It was assumed that the size and shape of the pelvis would vary with respect to body size. That is, there would be a tendency (recognizing the importance of human variation in any correlative study) for large pelves to be associated with large body size and small pelves to be associated with small body size. Churchill and McConville (2) have pointed out that body size can be represented by height and weight when attempting to match samples. As a result, specimens were selected from the Hamann-Todd skeletal collection on the basis of their height and weight with respect to the height/weight distribution in the Health and Examination Survey (HES) of 1961-1964 conducted by the U.S. Public Health Service (7). Only 18 to 55-year-old subjects in the HES raw anthropometric data were selected for analysis since it was reasoned they would be representative of the general U.S. population of the middle to late 1970's. These data were available for reanalysis on the computer system at the University of Michigan.

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The matching strategy was based upon the linear relationship between height and weight in the HES data. Figure 1 depicts the categories for both male and female body sizes. Each category is defined by the intersection of regression lines which divide the theoretical ellipsoid representing the height/weight distribution into six categories for each sex. Each category is coded so that they represent the following sizes:

1 - Small stature/Heavy weight
2 - Medium stature/Heavy weight
3 - Tall stature/Heavy weight
4 - Small stature/Light weight
5 - Medium stature/Light weight
6 - Tall stature/Light weight

These categories when combined into small (1 & 4), medium (2 & 5), and large (3 & 6) body sizes were established to divide the distribution into approximately 25 percent of the population at each of the extremes and 50 percent of the population in the middle (Table 1). The corresponding sample sizes in the matched Hamann-Todd specimens were selected to obtain subsamples large enough to represent each body size rather than to represent the distribution of body sizes in the general U.S. population.

TABLE 1. Sample Size In Each Size Cell By Sex

	MALE		FEMALE	
Size Cell	HES	H-T	HES	H-T
1	291 (11%)	7	320 (10%)	16
2	658 (24%)	17	651 (20%)	17
3	339 (12%)	14	322 (10%)	11
4	361 (13%)	13	446 (14%)	12
5	761 (28%)	17	997 (31%)	19
6	344 (12%)	12	476 (15%)	10
Total	2754 (100%)	80	3212 (100%)	85

Selecting subjects from the Hamann-Todd skeletal collection was complicated by the fact that their weights were extremely low for their heights. As a result, a constant of 12.7 kg (28 lbs) was added to the male weights and a constant of 14.1 kg (31 lbs) was added to the female weights. The constants represent differences by sex between the average weight for the 18 to 70-year-old males and females in the Health Examination Survey and the Hamann-Todd Skeletal collection. Table 2 reports the average height and weight by sex and size cell for both the Health Examination Survey subjects as well as the Hamann-Todd cadaver population. The difference between heights are minimal, but even in the correction for weight there are substantial differences. As previously pointed out, the size cells are defined primarily by height, and when the weight groups for the same heights are combined, the effect of weight is minimized on the categories defining body size.

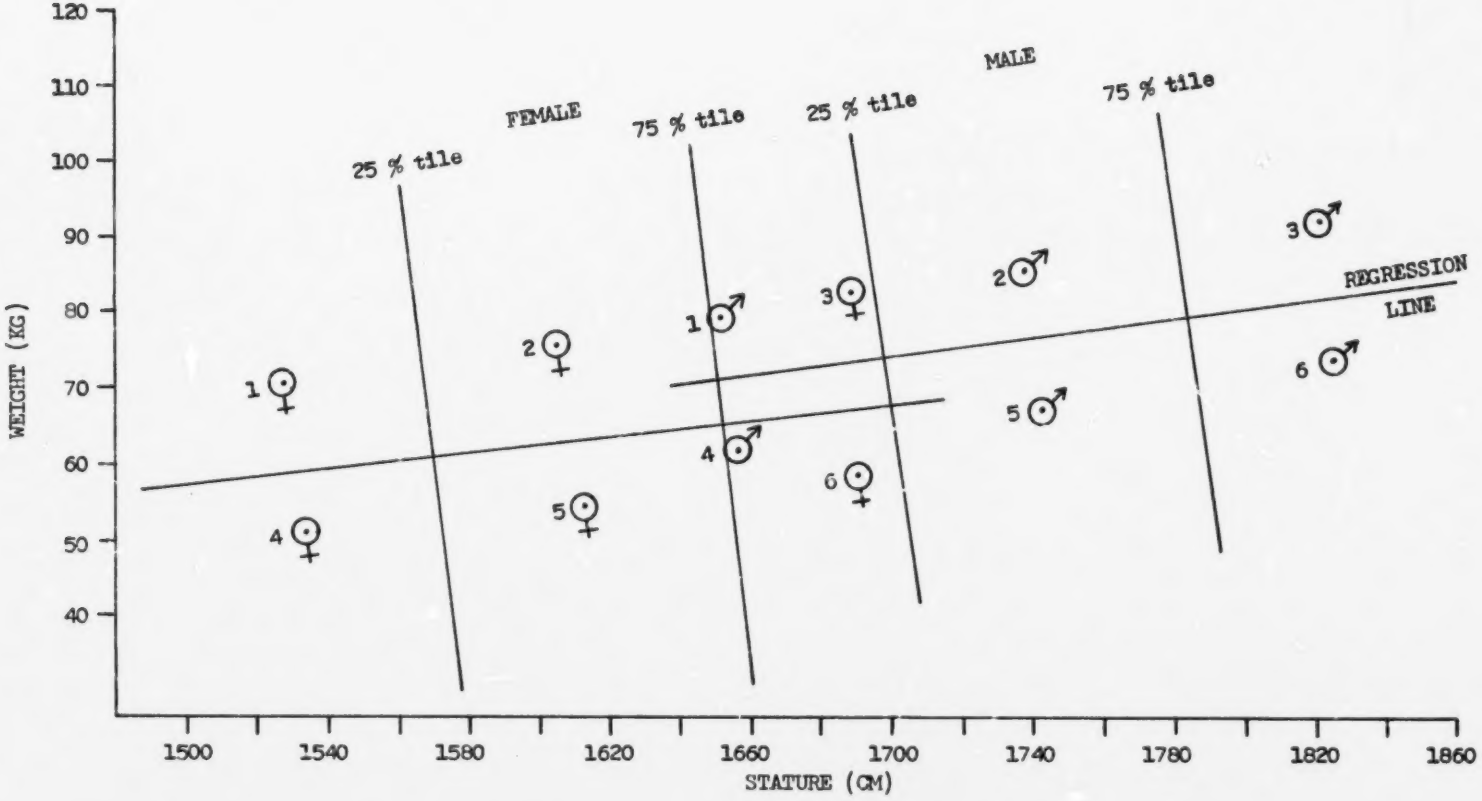

Figure 1. Sampling scheme for male and female specimens from the Hamann-Todd collection.

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TABLE 2. A Comparison of Height and Weight By Size Cell and Sex (Between HES and Hamann-Todd Specimens)

HEIGHT (cm)

Size Cell	MALE				FEMALE			
	HES		H-T		HES		H-T	
	Ave.	(S.D.)	Ave.	(S.D.)	Ave.	(S.D.)	Ave.	(S.D.)
1	164.6	(3.17)	165.1	(5.66)	152.6	(2.99)	151.5	(2.83)
2	173.5	(2.54)	172.9	(2.35)	160.2	(2.39)	160.4	(1.87)
3	182.0	(3.60)	182.8	(3.93)	168.7	(3.87)	169.1	(3.60)
4	164.9	(3.66)	164.1	(3.03)	152.5	(3.43)	153.9	(3.16)
5	173.9	(2.44)	174.4	(2.73)	160.9	(2.48)	161.5	(2.71)
6	182.5	(3.41)	184.8	(4.57)	168.9	(2.94)	170.7	(5.31)

WEIGHT (kg)*

Size Cell	MALE				FEMALE			
	HES		H-T		HES		H-T	
	Ave.	(S.D.)	Ave.	(S.D.)	Ave.	(S.D.)	Ave.	(S.D.)
1	79.0	(9.00)	78.7	(6.70)	71.7	(10.1)	74.8	(12.3)
2	85.9	(8.50)	83.1	(8.90)	77.3	(12.3)	73.8	(8.50)
3	92.7	(8.60)	91.5	(7.30)	82.3	(13.5)	78.7	(9.40)
4	62.1	(6.10)	63.3	(5.40)	52.4	(5.40)	46.9	(6.60)
5	67.6	(5.80)	67.6	(6.80)	55.8	(5.40)	54.1	(6.70)
6	74.0	(6.00)	76.1	(8.20)	59.4	(5.40)	56.4	(9.30)

*Values listed for both male and female H-T specimens include the weight adjusting constants.

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EXPERIMENTAL METHODS

Three-Dimensional Measuring

Following the reassembly of the pelvic ilia and sacral components into their correct anatomical position, a series of surface landmarks (Figures 2, 3, 4, and 5) for measurement procedures were placed on each specimen as defined in the listing of definitions (Appendix A). All surface landmark numbers shown in these figures refer to the X coordinate point number for each coordinate set. Specimens were first measured two-dimensionally by conventional methods, then measured in the three-dimensional format to establish the data base. Except for a few reference marks on the right hemipelvis, most of the landmarks were recorded on the left hemipelvis only. Assuming bilateral symmetry, the projection of left-registered points to the right side was accomplished by a computer program. The equipment used to register landmarks on the specimens consisted of a Hewlett-Packard Model 9864A digitizer with input into a Hewlett-Packard Model 9820A calculator. This system was modified by attaching a diagraph to the digitizing curser of the plotting board so that the diagraph needle would be directly vertical to the crosshairs of the digitizer at all times. A potentiometer on the diagraph registers the height of the needle above the plotting board and provides Z - axis data to the computer. The specimen was suspended over the board in a position allowing access to all of the landmarks on the bone. The diagraph is maneuvered so that the needle is in contact with a given landmark. A single signal, activated on the digitizer, registers the X, Y, and Z coordinates of the landmark in relation to an origin point on the board. The spatial location of each registered landmark can then be transformed in reference to an anatomical axis system which is based on a transverse plane formed by Symphysion and the left and right Anterior-Superior Iliac Spines.

Repeated calibration runs on test specimens revealed a mean accuracy of ± 0.5 mm on computed point-to-point linear measurements. Such accuracy exceeds that obtained by conventional osteological techniques.

Three-Dimensional Modeling

One objective of this study was to provide a series of full-scale, anatomically correct pelvic models for use in the design of anthropomorphic test devices. Master models for the small female, medium male, and large male, as defined by the three-dimensional data, were first sculptured in clay, then duplicated in epoxy by a casting technique.

The modeling technique used a procedure similar to that in measuring the original specimens for three-dimensional data, except in reverse. From a series of five computer-generated Y - Z coordinate point plots (unilateral format) for each pelvis size, a bilateral composite (mirror image) plot was made on transparent plastic and mounted on a horizontally stabilized plate glass surface. A thin, rigid aluminum and plaster gauze framework was constructed for each model size to internally support and stabilize the irregular soft clay form. The framework was aligned and suspended above the composite Y - Z plot so that the orientation of the model Y - Z plane would

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Lateral View

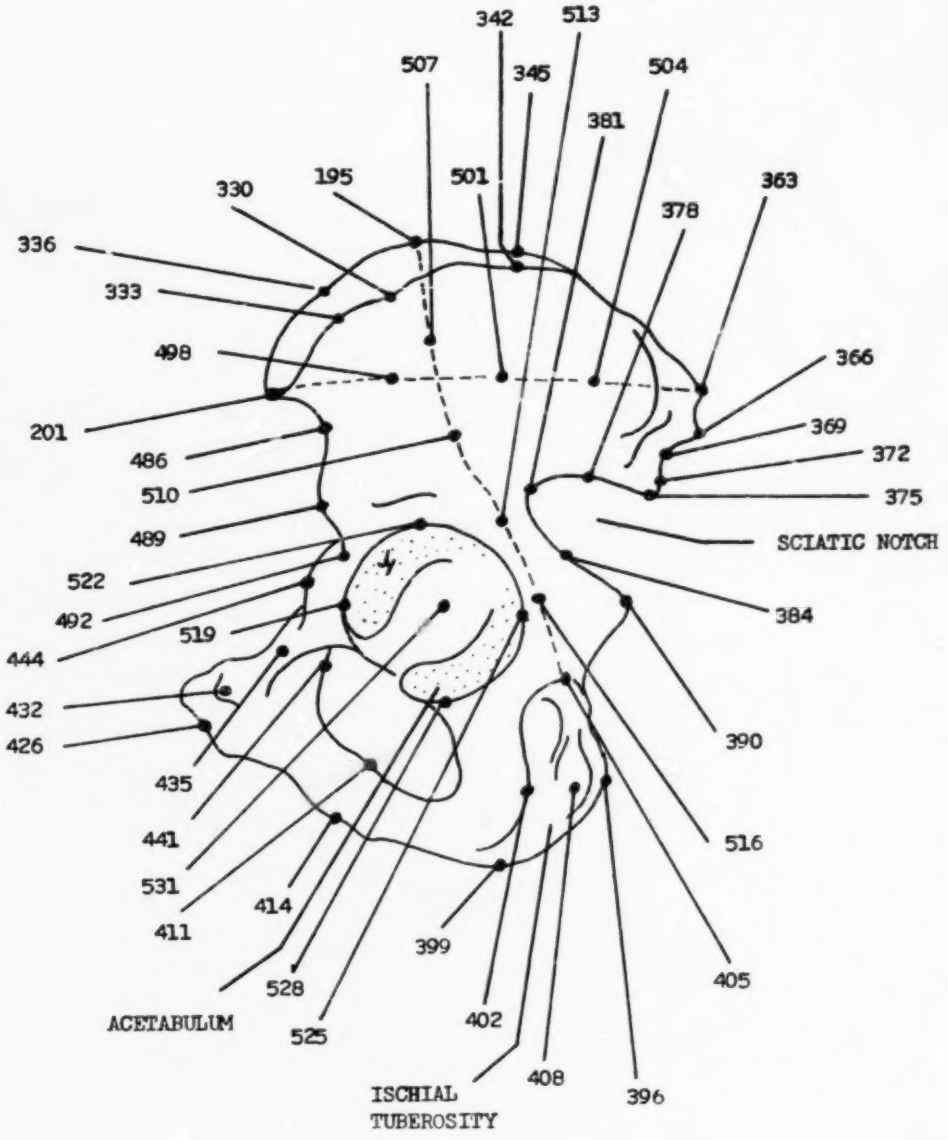

Figure 2. 3-Dimensional data points for pelvis: Left side.

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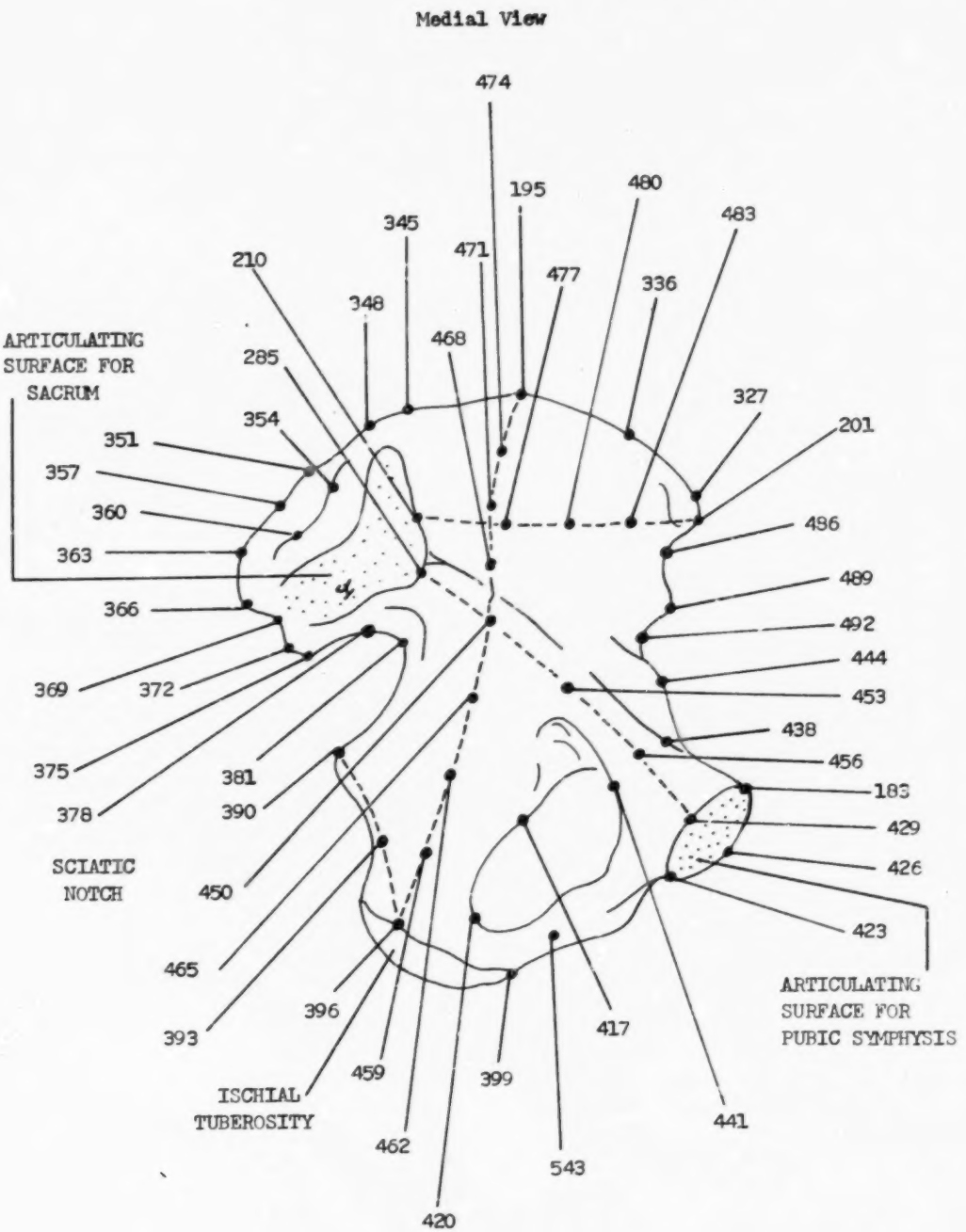

Figure 3. 3-Dimensional data points for pelvis: Left side.

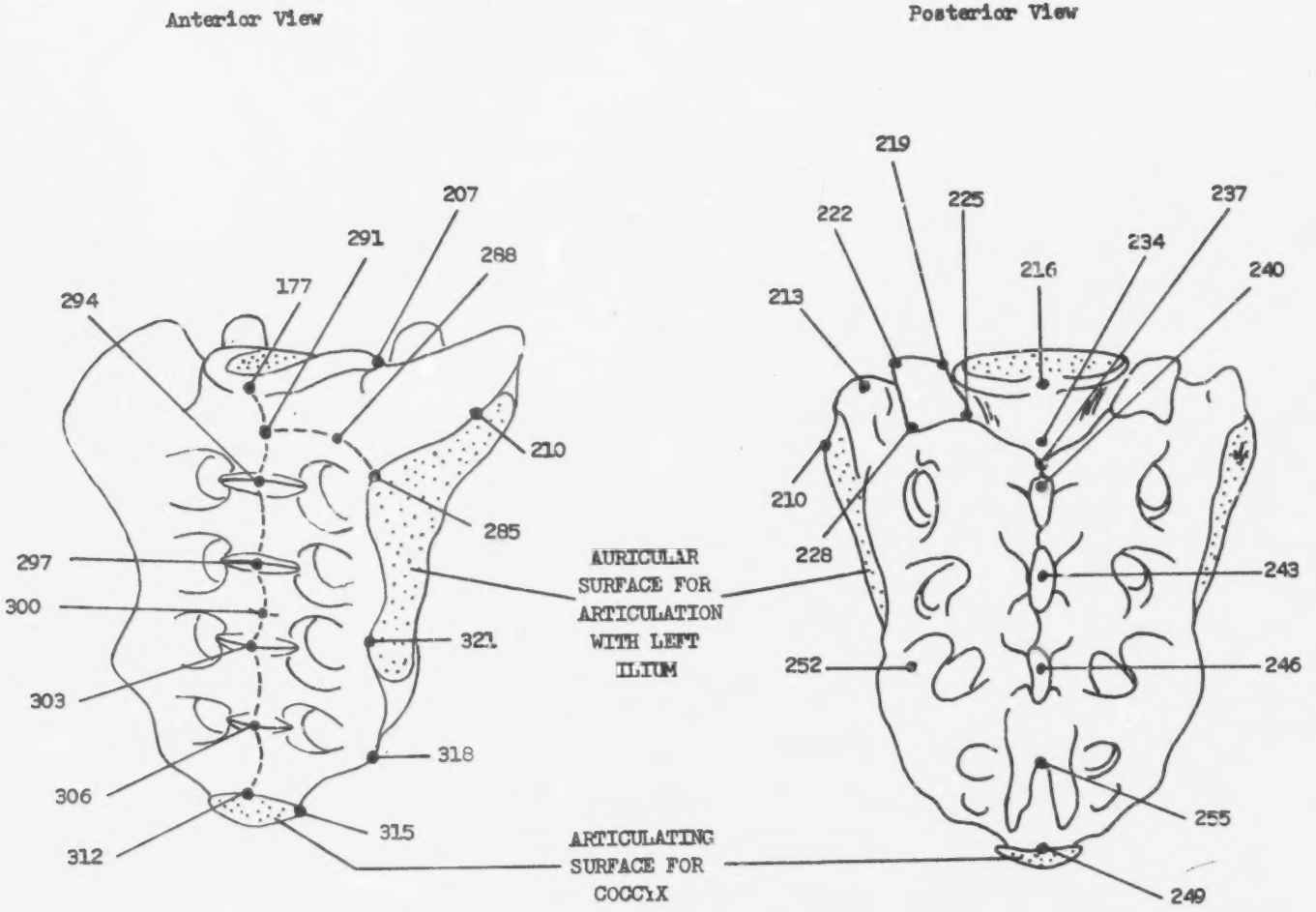

Figure 4. 3-Dimensional data points for sacrum.

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Superior View

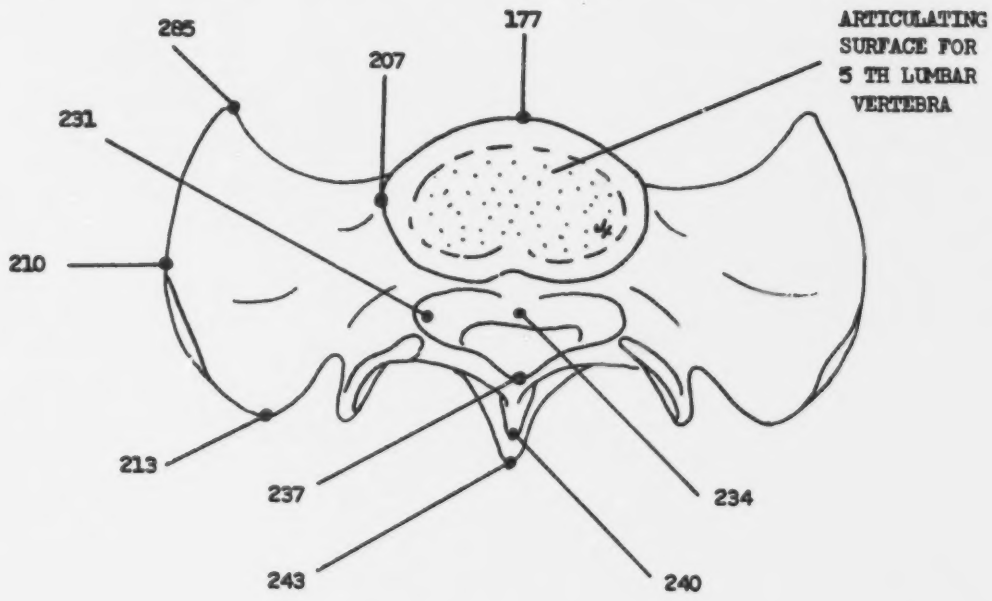

Figure 5. 3-Dimensional data points for sacrum.

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be parallel to that of the plot surface. The pelvis model Y - Z plane (Figure 6), defined by the bilateral Anterior Superior Iliac Spine points (201) and the midsagittal Symphysion point (204), is the origin reference plane for all vertical X distance values. Using a diagraph instrument, the lower fixed pointer was aligned with a Y - Z coordinate plot point, then the upper movable pointer was raised vertically to the appropriate X height value. The clay was extended and shaped to make surface contact with the upper pointer which defined the spatial location of that point. This procedure was repeated for all coordinate points to establish the three-dimensional characteristics of the complete pelvis. Surface contouring between the coordinate point locations was accomplished on the basis of experienced judgment to be anatomically correct, but omitting fine detail which would serve no practical function.

The final epoxy models (Appendix B) were produced by the Eoanthropus Memorial Casting Laboratory, Santa Fe, New Mexico, which was also responsible for the design and fabrication of the casting molds for the master clay models. A dimensional accuracy of a ± 2 millimeters for the final epoxy models is within typical limits of the combined measurement error of anatomical specimens and variations in naturally occurring bilateral asymmetry.

DATA ANALYSIS

Upon completion of the measurements at the Civil Aeromedical Institute (CAMI), the data were entered into the University of Michigan computer system where all subsequent data analysis was performed. Since the data were obtained with each specimen in a rigid but controlled position with respect to the three-dimensional anthropometer and its three-dimensional axis system, a comparable anatomical axis system (6) was established for each specimen. The axis system is defined by three landmarks: right and left anterior superior iliac spines (201) and symphysion (204) (as shown in Figure 6).

These three points define the Y - Z plane in the following manner: construct a line passing from right to left Anterior Superior Iliac Spines to establish the +Y axis. Next establish a perpendicular to the Y axis passing through Symphysion (204) in a -Z direction. The intersection of the Y and Z axes establishes the origin of the axis system and a +X axis is defined normal to the Y - Z plane according to the right-hand rule. All data are then transformed into the new axis system.

Data were checked for keypunch errors and erroneous values through use of X - VAL (3). This editing program outputs extreme values for each variable in addition to useful summary statistics which allow the user to visually check the data for outliers in each variable. Because of the reliability of the three-dimensional anthropometer, there have been no errors detected to date that can be attributed to electrical read errors within the measurement system. There were a few keypunch errors detected and corrections were made. A more serious error is obvious in the data which has been attributed to the axis system definition methodology. That is, when only three points in the axis system definition exist, slight differences caused by observer error or variability in the pelvis itself can produce a significant effect on the new data coordinates (8). This source of variability has not been investigated to determine an optimum axis system definition, and subsequent analyses may provide slightly different results than those reported in this study.

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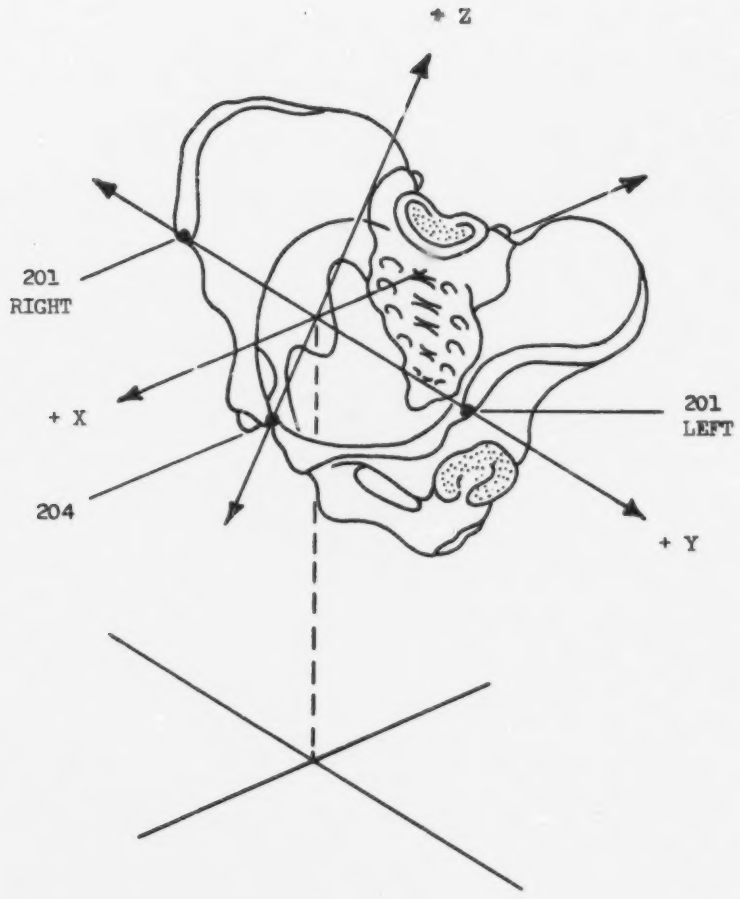

Figure 6. Pelvic axes system. Direction of axes, coordinate definitions, and pelvis orientation relative to a standing anatomical position.

Following completion of the data edit, specimens were combined into the assigned size cells discussed previously. The grouped data for small (size cells 1 and 4), medium (size cells 2 and 5), and large (size cells 3 and 6) pelves were statistically summarized. These summary statistics (mean and standard deviation) were computed for the coordinate of each point. Since there were three (X, Y, Z) coordinates for each of the 123 points, a total of 369 variables were computed for the statistical summary. These data are reported in Appendix C.

In order to utilize these data for constructing the anatomical models, two-dimensional coordinate plots of the Y - Z plane were generated so that a perpendicular (X axis coordinate) defines a point above the plane for use by the sculpturer. There were five plots generated with three points in common on each plot: Promontorion (point 177 in Figure 4), Left Iliospinale, Summum (point 201), and Symphysion (point 204). These three points provided a means of aligning each plot in the same relative position to construct a complete bilateral composite plot for sculpturing procedures.

CONCLUSION

In conclusion, these data will provide an estimate of the variation in pelvic geometry within the adult male and female civilian U.S. population. The definition of axes systems using anatomical landmarks needs relatively "stable," palpable landmarks that are commensurately distant. This information can be obtained in a reasonably large scruple representative of extreme body sizes in the general U.S. civilian population. Uses of these data will include specification of representative pelves for various sizes of anthropomorphic test devices, identification and description of cadavers in forensic investigations, and quantitative information on the shape and size variability of the adult human pelvis.

APPENDIX A

DEFINITIONS OF PELVIC LANDMARKS

Each descriptive surface landmark (measuring point) used in this study is identified in three-dimensional space as a set of three sequential numbers to represent the X, Y, and Z coordinate values. The first number in each set refers to the X coordinate value and is always used as the identifying reference number for each measurement point. These sequential number sets appear with each of the following measurement point definitions.

Promontorion 177-179: The midpoint of the anterior-superior margin of the first sacral segment (excluding exostoses).

Right Superior Pole, Pubic Symphysis 180-182: The point at the intersection of the longitudinal midline axis of the pubic symphysis with the superior margin of the symphyseal face of the right innominate bone.

Left Superior Pole, Pubic Symphysis 183-185: The point at the intersection of the longitudinal midline axis of the pubic symphysis with the superior margin of the symphyseal face of the left innominate bone.

Ischiale 186-188: The innominate rests on its medial surface with the iliac blade and pubic symphysis in contact with the horizontal surface of an osteometric board. Move the bone into the right angle corner of the board in such a way that the superior border of the iliac crest is in contact with one of the vertical plates and the anterior border of the iliac crest and the pubic bone are in contact with the second vertical plate of the osteometric board. Ischiale is the highest point on the ischial tuberosity when the innominate bone is in the correct position.

H-Point 189-191: A plexiglass hemisphere is selected which best fits the acetabulum of the left innominate. The hemisphere is positioned so that the anterior extremity of one of the perpendicular diameter lines is opposite Point 519 (Acetabulion Anterior). H-Point is the center point of the hemisphere surface.

Iliocristale, Posterior 192-194: The innominate rests on its medial surface with the iliac blade and pubic symphysis in contact with the horizontal surface of an osteometric board. Move the bone into the right angle corner of the board in such a way that the superior border of the iliac crest is in contact with one of the vertical plates and the anterior border of the iliac crest and the pubic bone are in contact with the second vertical plate of the osteometric board. Iliocristale Posterior, the posterior superior iliac spine, is defined as the point along the posterior border of the iliac crest in contact with the vertical plate of the osteometric board. In cases where a large area is in contact with the board, the landmark is taken as the midpoint of the contact area.

Iliocristale, Summum 195-197: The innominate rests on its medial surface with the iliac blade and pubic symphysis in contact with the horizontal surface of an osteometric board. The bone is moved into the right angle corner of the board in such a way that the superior border of the iliac crest is in contact with one of the vertical plates and the anterior border of the iliac crest and the pubic bone are in contact with the second vertical plate of the osteometric board. Iliocristale Summum is defined as the point along the superior border of the iliac crest that is in contact with a movable vertical plate oriented at right angles to the vertical plates of the osteometric board. In cases where a large area is in contact with the board, the landmark is taken as the midpoint of the contact area.

Right Iliospinale, Summum 198-200: The right innominate rests on its medial surface with the iliac blade and pubic symphysis in contact with the horizontal surface of an osteometric board. Move the bone into the right angle corner of the board in such a way that the superior border of the iliac crest is in contact with one of the vertical plates and the anterior border of the iliac crest and the pubic bone are in contact with the second vertical plate of the osteometric board. Iliospinale Summum, the anterior superior iliac spine, is defined as the point along the anterior border of the iliac crest in contact with the vertical plate. In cases where a large area is in contact with the board, the landmark is taken as the midpoint of the contact area.

Left Iliospinale, Summum 201-203: The left innominate rests on its medial surface with the iliac blade and pubic symphysis in contact with the horizontal surface of an osteometric board. Move the bone into the right corner of the board in such a way that the superior border of the iliac crest is in contact with one of the vertical plates and the anterior border of the iliac crest and the pubic bone are in contact with the second vertical plate of the osteometric board. Iliospinale Summum, the anterior superior iliac spine, is defined as the point along the anterior border of the iliac crest in contact with the vertical plate. In cases where a large area is in contact with the board, the landmark is taken as the midpoint of the contact area.

Symphysion 204-206: This point is the midpoint of a line between point 180, Right Superior Pole, Pubic Symphysis, and point 183, Left Superior Pole, Pubic Symphysis. It is not a landmark that is measured, but a point in space that is mathematically constructed.

Lateral Point on First Sacral Vertebral Body 207-209: The most lateral point on the left articular surface of the first sacral body. In cases with "lipping" present, the point was estimated as the most lateral point on the superior surface that would be found in the general contour that would have been found without any "lipping."

Lateral Alar-Auricular Point 210-212: The point is found on the superior aspect as the most lateral point along the superior margin of the articular surface.

Posterior Alar-Auricular Point 213-215: The point is found on the superior aspect as the most postero-lateral boney projection on the wing of the sacrum.

Posterior Point on First Sacral Vertebral Body 216-218: The midpoint of the postero-superior margin of the first sacral segment. This point is posterior to Promontorion, point 177.

Superior Articular Facet: Medial Superior 219-221: The most superior point on the medial side of the superior articular facet of the sacrum.

Superior Articular Facet: Lateral Superior 222-224: The most superior point on the lateral side of the superior articular facet of the sacrum.

Superior Articular Facet: Medial Inferior 225-227: The most inferior point on the medial side of the superior articular facet of the sacrum.

Superior Articular Facet: Lateral Inferior 228-230: The most inferior point on the lateral side of the superior articular facet of the sacrum.

Sacral Canal, Anterior Wall 231-233: The most lateral point on the lateral wall of the sacral canal. This point is found when the sacrum is oriented such that Point 177, Promontorion, Point 207, Lateral Point on First Sacral Vertebral Body, and Point 216, Posterior Point on First Sacral Vertebral Body, form a horizontal plane. The sacrum is viewed in the posterior aspect.

Sacral Canal, Anterior Floor 234-236: The sacrum is viewed in the posterior aspect while the sacrum is oriented in a horizontal plane defined by Point 177, Promontorion; Point 207, Lateral Point on First Sacral Vertebral Body; and Point 216, Posterior Point on First Sacral Vertebral Body. The landmark is defined as a point on the posterior body of the first sacral vertebral body at the intersection of a horizontal plane tangent to the anterior roof point of the sacral canal (Point 237) and a perpendicular line passing through the Posterior point on the First Sacral Vertebral Body Point 216.

Sacral Canal, Anterior Roof 237-239: The most anterior-superior point of the roof of the sacral canal.

Dorsal Spine of the First Sacral Vertebra 240-242: The most posterior point on the dorsal spine of the first sacral segment. In the instance of a continuous boney ridge, the point is estimated by reference to the superior and inferior margins of the laminar plates that join to form the dorsal spines.

Dorsal Spine of the Second Sacral Vertebra 243-245: The most posterior point on the dorsal spine of the second sacral segment. In the instance of a continuous boney ridge, the point is estimated by reference to the superior and inferior margins of the laminar plates that join to form the dorsal spines.

Dorsal Spine of the Third Sacral Vertebra 246-248: The most posterior point on the dorsal spine of the third sacral segment. In the instance of a continuous boney ridge, the point is estimated by reference to the superior and inferior margins of the laminar plates that join to form the dorsal spines.

Caudion, Posterior 249-251: The midpoint of the posterior-inferior margin of the last sacral segment. Morphological observations of the sacral segments should be examined to determine the exact sacral or coccygeal vertebrae upon which Point Caudion is located.

Posterior Sacral Tubercle 252-254: The sacrum is viewed from the lateral aspect while oriented in a horizontal plane defined by Point 177, Promontorion; Point 207, Lateral Point on First Sacral Vertebral Body; and Point 216, Posterior Point on First Sacral Vertebral Body. The landmark is defined as the most posterior point on the posterior sacral tubercle adjacent to the second vertebral foramen.

Sacral Canal, Posterior Roof 255-257: The point is located in the mid-sagittal plane at the most inferior aspect of the sacral canal roof.

Standard Reference Point 258-260: A point for instrumentation calibration.

Sacroiliac Midpoint 261-263: The point that lies at the intersect of the lines which bisect the superior and inferior poles of the sacroiliac joint.

Superior Lobe, Inferior Margin Midpoint 264-266: A point along the inferior margin of the superior pole of the sacroiliac joint surface that lies on a perpendicular line that bisects the line passing between Point 261, Sacroiliac Midpoint, and Point 267, Superior Pole.

Superior Pole 267-269: A point on the posterior margin of the sacroiliac joint surface that lies on a line bisecting the superior pole of the joint surface.

Superior Lobe, Superior Margin Midpoint 270-272: A point along the superior margin of the superior pole of the sacroiliac joint surface that lies on a perpendicular line that bisects the line passing between Point 261, Sacroiliac Midpoint, and Point 267, Superior Pole.

Inferior Lobe, Anterior Margin 273-275: A point along the anterior margin of the inferior lobe of the sacroiliac joint surface that lies on a perpendicular line bisecting the line between Point 261, Sacroiliac Midpoint, and Point 276, Inferior Pole.

Inferior Pole 276-278: A point on the inferior margin which lies on a line bisecting the inferior pole of the sacroiliac joint.

Inferior Lobe, Posterior Margin 279-281: A point along the posterior margin of the inferior lobe that lies on a perpendicular line bisecting the line between Point 261, Sacroiliac Midpoint, and Point 276, Inferior Pole.

Posterior Angle 282-284: The most anterior point along the posterior margin of the sacroiliac joint.

Anterior Alar Point 285-287: This point is found on the lateral aspect of the sacrum and is defined as the most anterior point on the anterior margin of the articular surface of the sacroiliac joint.

Mid-Alar Point 288-290: This point is defined on the anterior aspect of the sacrum as the midpoint of a line on the anterior surface of the alar wing between Point 291, Center of First Sacral Vertebral Body, and Point 285, Anterior Alar Point.

Center of First Sacral Vertebral Body 291-293: This point lies on the base of the sacrum equidistant between Point 177, Promontorion, and Point 216, Posterior Point on the First Sacral Body.

First Sacral Segment Union Point 294-296: This point lies in the midline of the sacrum defined as a line passing equidistant between segment sacral apertures (medial edge of vertebral canals). The first union point is located at the intersection of the vertical midline axis and the anatomical union of the first and second sacral vertebrae. If this closure is incomplete, the point is reconstructed in clay midway between adjacent vertebrae. This point is based on anatomical, not topographical, observations and is an estimate of osteological closure lines. The point may not be located at the most anterior aspect of this union area.

Second Sacral Segment Union Point 297-299: This point lies in the midline of the sacrum defined as a line passing equidistant between segment sacral apertures (medial edge of vertebral canals). The second union point is located at the intersection of the vertical midline axis and the anatomical union of the second and third sacral vertebrae. If this closure is incomplete, the point is reconstructed in clay midway between adjacent vertebrae. This point is based on anatomical, not topographical, observations and is an estimate of osteological closure lines. The point may not be located at the most anterior aspect of this union area.

Inflexion 300-302: This point is located at the intersection of the longest perpendiculars from the two extreme anterior ends of the sacrum. Inflexion is a geometric point which uses either L5 or S1 at the proximal end and Caudion at the distal end.

Third Sacral Segment Union Point 303-305: This point lies in the midline of the sacrum defined as a line passing equidistant between segment sacral apertures (medial edge of vertebral canals). The third union point is located at the intersection of the vertical midline axis and the anatomical union of the third and fourth sacral vertebrae. If this closure is incomplete, the point is reconstructed in clay midway between adjacent vertebrae. This point is based on anatomical, not topographical, observations and is an estimate of osteological closure lines. The point may not be located at the most anterior aspect of this union area.

Fourth Sacral Segment Union Point 306-308: This point lies in the midline of the sacrum defined as a line passing equidistant between segment sacral apertures (medial edge of vertebral canals). The fourth union point is located at the intersection of the vertical midline axis and the anatomical

union of the fourth and fifth sacral vertebrae. If this closure is incomplete, the point is reconstructed in clay midway between adjacent vertebrae. This point is based on anatomical, not topological, observations and is an estimate of osteological closure lines. The point may not be located at the most anterior aspect of this union area.

Fifth Sacral Segment Union Point 309-311: This point lies in the midline of the sacrum defined as a line passing equidistant between segment sacral apertures (medial edge of vertebral canals). The fifth union point is located at the intersection of the vertical midline axis and the anatomical union of the fifth and sixth sacral vertebrae. If this closure is incomplete, the point is reconstructed in clay midway between adjacent vertebrae. This point is based on anatomical, not topographical, observations and is an estimate of osteological closure lines. The point may not be located at the most anterior aspect of this union area.

Caudion, Anterior 312-314: This point is at the midpoint of the anteroinferior margin of the last sacral segment.

Caudion, Lateral 315-317: This point is the most lateral point on the inferior margin of the last sacral segment.

Inferior Sacral Angle 318-320: This point is located and viewed anteriorly at the intersection of lines approximating the latero-inferior aspect of the sacral body and the inferior margin of the sacral body.

Inferior Sacroiliac Junction 321-323: A point on the anterior edge of the sacroiliac joint where the inferior curve of the sacral articular margin intersects the anterior sacral surface.

Standard Reference Point 324-326: A point for instrumentation calibration.

Iliospinale, Cristale 327-329: This point is observed in a posterior-anterior view across the iliac blade. It is defined as the most medial point on the medial margin of the anterior portion of the iliac crest.

Iliocristale, Anterior Lateral 330-332: The most lateral point on the lateral border of the iliac crest in the iliac pillar.

Anterior Segment Midpoint, Lateral 333-335: A point that is located at the intersection of the lateral iliac crest edge and a line bisecting and perpendicular to a line passing through Point 339, Iliocristale Summum, and Point 201, Right Iliospinale Summum.

Anterior Segment Midpoint, Medial 336-338: A point that is located at the intersection of the medial iliac crest edge and a line bisecting and perpendicular to a line passing through Point 339, Iliocristale Summum, and Point 201, Right Iliospinale Summum.

Iliocristale, Summum 339-341: The right innominate rests on its medial surface with the iliac blade and pubic symphysis in contact with the horizontal surface of an osteometric board. The innominate is moved into the right angle corner of the board in such a way that the superior border of

the iliac crest is in contact with one of the vertical plates and the anterior border of the iliac crest and the pubic bone are in contact with the second vertical plate of the osteometric board. Iliocristale Summum is defined as the point along the superior border of the iliac crest in contact with the vertical plate. In instances where a large area is in contact with the plate, the landmark is taken as the midpoint of the contact area.

Posterior Segment Point, Lateral 1 342-344: Between Point 339, Iliocristale Summum, and Point 366, Posterior Superior Iliospinale, on the iliac crest surface, three equidistant marks are made as perpendicular projections intersecting the medial and lateral margins. Lateral 1 point is located at the intersection of the most anterior mark and the lateral crest margin.

Posterior Segment Point, Medial 1 345-347: Between Point 339, Iliocristale Summum, and Point 366, Posterior Superior Iliospinale, on the iliac crest surface, three equidistant marks are made as perpendicular projections intersecting the medial and lateral margins. Medial 1 point is located at the intersection of the most anterior mark and the medial crest margin.

Iliocristale, Posterior Medial 348-350: This point is located where the posterior margin of the iliac fossa intersects the medial margin of the iliac crest.

Posterior Segment Point, Lateral 2 351-353: Between Point 339, Iliocristale Summum, and Point 366, Posterior Superior Iliospinale, on the iliac crest surface, three equidistant marks are made as perpendicular projections intersecting the medial and lateral margins. Lateral 2 point is located at the intersection of the middle mark and the lateral crest margin.

Posterior Segment Point, Medial 2 354-356: Between Point 339, Iliocristale Summum, and Point 366, Posterior Superior Iliospinale, on the iliac crest surface, three equidistant marks are made as perpendicular projections intersecting the medial and lateral margins. Medial 2 point is located at the intersection of the middle mark and the medial crest margin.

Posterior Segment Point, Lateral 3 357-359: Between Point 339, Iliocristale Summum, and Point 366, Posterior Superior Iliospinale, on the iliac crest surface, three equidistant marks are made as perpendicular projections intersecting the medial and lateral margins. Lateral 3 point is located at the intersection of the most posterior mark and the lateral crest margin.

Posterior Segment Point, Medial 3 360-362: Between Point 339, Iliocristale Summum, and Point 366, Posterior Superior Iliospinale, on the iliac crest surface, three equidistant marks are made as perpendicular projections intersecting the medial and lateral margins. Medial 3 point is located at the intersection of the most posterior mark and the medial crest margin.

Iliocristale, Posterior 363-365: The right innominate bone rests on its medial surface with the iliac blade and pubic symphysis in contact with the

horizontal surface of an osteometric board. The bone is moved into the right angle corner of the board in such a way that the superior border of the iliac crest is in contact with one of the vertical plates and the anterior border of the iliac crest and the pubic bone are in contact with the second vertical plate of the osteometric board. Iliocristale, Posterior, is defined on the iliac crest as equidistant between Point 366, Iliospinale Posterior, and Point 339, Iliocristale Summum.

Posterior Superior Iliospinale 366-368: The right innominate bone rests on its medial surface with the iliac blade and pubic symphysis in contact with the horizontal surface of an osteometric board. The bone is moved into the right angle corner of the board in such a way that the superior border of the iliac crest is in contact with one of the vertical plates and the anterior border of the iliac crest and the pubic bone are in contact with the second vertical plate of the osteometric board. Posterior Superior Iliospinale, the posterior superior iliac spine, is defined as the point along the posterior border of the iliac crest in contact with a movable vertical plate oriented at right angles to the vertical plates of the osteometric board. In instances where a large area is in contact with the board, the landmark is taken as the midpoint of the contact area.

Posterior Iliac Notch Point 369-371: The deepest point on the posterior iliac border between Point 366, Posterior Superior Iliospinale, and Point 372, Posterior Inferior Iliospinale.

Posterior Inferior Iliospinale 372-374: The most projecting point on the posterior auricular margin.

Bouisson Tubercle 375-377: The most prominent point on the tubercle of Bouisson located at the apex of a tubercle formed by the origin of m. piriformis.

Superior Sciatic Notch Point 378-380: The point equidistant between Point 381, Apex of Sciatic Notch, and Point 375, Bouisson Tubercle. It is on the superior margin of the sciatic notch.

Apex of Sciatic Notch 381-383: The point on the sciatic notch border at the greatest perpendicular distance from a projected line between Point 372, Posterior Inferior Iliospinale, and Point 390, Ischial Spinale.

Anterior Sciatic Notch Point 384-386: The point on the inferior margin of the sciatic notch midway between Point 390, Ischial Spinale, and Point 381, Apex of the Sciatic Notch.

Standard Reference Point 387-389: A point for instrumentation calibration.

Ischio-Spinale 390-392: The superior posterior angle of the ischial spine.

Posterior Ischial Border Point 393-395: The point on the posterior margin of the ischial border equidistant between Point 390, Ischio-Spinale, and Point 396, Medial Tuberosity Point.

Medial Tuberosity Point 396-398: The most medial point on the medial margin of the ischial tuberosity when the innominate is oriented in the anatomical position.

Inferior Tuberosity Point 399-401: The point of convergence of the medial and lateral margins of the ischial tuberosity.

Lateral Tuberosity Point 402-404: The most lateral point on the lateral margin of the ischial tuberosity with the innominate held in the anatomical position.

Superior Tuberosity Point 405-407: The most superior point on the margin of the ischial tuberosity with the innominate held in the anatomical position and viewed from the lateral aspect.

Ischiale 408-410: The right innominate rests on its medial surface with the iliac blade and pubic symphysis in contact with the horizontal surface of an osteometric board. The bone is moved into the right angle corner of the board in such a way that the superior border of the iliac crest is in contact with one of the vertical plates and the anterior border of the iliac crest and the pubic bone are in contact with the second vertical plate of the osteometric board. Ischiale is defined as the highest point on the ischial tubercosity from the surface of the osteometric board.

Superior Ischial Pubic Ramus 411-413: The point equidistant between Point 180, Right Superior Pole, Pubic Symphysis, and Point 408, Ischiale, on the superior margin of the ischial pubic ramus.

Anterior Inferior Ischial Pubic Ramus 414-416: A point on the anterior inferior margin of the ischial pubic ramus passing through Point 411, Superior Ischial Pubic Ramus, at right angles to the line joining Point 180, Right Superior Pole, Pubic Symphysis, and Point 408, Ischiale.

Obturator Tubercle Point 417-419: The point on the lateral margin of the obturator foramen generally marked by a small tubercle. In instances where there are two tubercles, the apex of the most superior tubercle is marked as the point with the innominate oriented in the anatomical position.

Inferior Obturator Foramen Point 420-422: The point at which the greatest curvature occurs on the posterior-inferior margin of the obturator foramen.

Inferior Symphyseal Pole 423-425: This point is located at the inferior intersection of the anterior and posterior margins of the symphyseal surface.

Anterior Symphyseal Point 426-428: This point is located on the anterior margin of the pubic symphysis where it is intersected by a line perpendicular to the longitudinal axis equidistant between the polar Points 180 and 423.

Posterior Symphyseal Point 429-431: This point is located on the anterior margin of the pubic symphysis where it is intersected by a line perpendicular to the longitudinal axis equidistant between polar Points 180 and 423.

Pubotubercle 432-434: This point is located at the anterior most projecting point of the summit of the pubic tubercle with the innominate oriented in the anatomical position.

Anterior Pubic Ramus Point 435-437: The point on the anterior surface of the pubic ramus marking the intersection of a line passing through Point 456, Anterior Inlet Point, at right angles to the line of the pelvic inlet and the line extending from Point 432, Pubotubercle, to Point 519, Acetabulion, Anterior.

Superior Pubic Ramus Point 438-440: A point on the margin of the pubic crest crossed by a line passing through Point 456, Anterior Inlet Point, at right angles to the line of the pelvic inlet.

Inferior Pubic Ramus Point 441-443: The point on the superior border of the obturator foramen crossed by a line passing through Point 456, Anterior Inlet Point, at right angles to the pelvic inlet line.

Pubic Eminence Point 444-446: The summit of the ilio-pectineal eminence.

Standard Reference Point 447-449: A point for instrumentation calibration.

Posterior Inlet Point 450-452: The posterior most point subdividing a straight line into four equidistant segments from Point 285, Anterior Alar Point, to Point 429, Posterior Symphyseal Point.

Intermediate Inlet Point 453-455: The intermediate most point subdividing a straight line into four equidistant segments from Point 285, Anterior Alar Point, to Point 429, Posterior Symphyseal Point.

Anterior Inlet Point 456-458: The anterior most point subdividing a straight line into four equidistant segments from Point 285, Anterior Alar Point, to Point 429, Posterior Symphyseal Point.

Inferior Ischial Inner Surface Point 459-461: The inferior most point of three equidistant points dividing a straight line between Point 396, Medial Tuberosity Point, and Point 450, Posterior Inlet Point, into four equal segments.

Intermediate Ischial Inner Surface Point 462-464: The intermediate most point of three equidistant points dividing a straight line between Point 396, Medial Tuberosity Point, and Point 450, Posterior Inlet Point, into four equal segments.

Superior Ischial Inner Surface Point 465-467: The superior most point of three equidistant points dividing a straight line between Point 396, Medial Tuberosity Point, and Point 450, Posterior Inlet Point, into four equal segments.

Inferior Vertical Iliac Fossa Contour Point 468-470: The inferior most point of three equidistant points dividing a straight line between Point 339, Iliocristale Summum, to Point 450, Posterior Inlet Point, into four equal segments.

Intermediate Vertical Iliac Fossa Contour Point 471-473: The intermediate most point of three equidistant points dividing a straight line from Point 339, Iliocristale Summum, to Point 450, Posterior Inlet Point, into four equal segments.

Superior Vertical Iliac Fossa Contour Point 474-476: The superior most point of three equidistant points dividing a straight line from Point 339, Iliocristale Summum, to Point 450, Posterior Inlet Point, into four equal segments.

Posterior Transverse Iliac Fossa Contour Point 477-479: The posterior most point of three equidistant points dividing a straight line from Point 210, Lateral Alar-Auricular Point, to Point 366, Posterior Superior Iliospinale, into four equal segments.

Intermediate Transverse Iliac Fossa Contour Point 480-482: The intermediate most point of three equidistant points dividing a straight line from Point 210, Lateral Alar-Auricular Point, to Point 366, Posterior Superior Iliospinale, into four equal segments.

Anterior Transverse Iliac Fossa Contour Point 483-485: The anterior most point of three equidistant points dividing a straight line from Point 210, Lateral Alar-Auricular Point, to Point 366, Posterior Superior Iliospinale, into four equal segments.

Anterior Iliac Notch Point 486-488: The point of deepest indentation of the anterior iliac border between Point 198, Right Iliospinale Summum, and Point 489, Anterior Inferior Iliospinale.

Iliospinale, Anterior Inferior 489-491: This point is located at the apex of the anterior border of the anterior inferior iliac spine as viewed from the medial aspect of the innominate.

Anterior Iliac Base Point 492-494: This point is found at the apex of the angle formed by the inferior terminus of the anterior iliac margin and the superior surface of the acetabular margin at the base of the ilium.

Standard Reference Point 495-497: A point for instrumentation calibration.

Anterior Transverse Lateral Iliac Surface Contour Point 498-500: The anterior most point of three equidistant points dividing a straight line extending from Point 199, Right Iliospinale Summum, to Point 366, Posterior Superior Iliospinale, into four equal segments.

Intermediate Transverse Lateral Iliac Surface Contour Point 501-503: The intermediate most point of three equidistant points dividing a straight line extending from Point 199, Right Iliospinale Summum, to Point 366, Posterior Superior Iliospinale, into four equal segments.

Posterior Transverse Lateral Iliac Surface Contour Point 504-506: The posterior most point of three equidistant points dividing a straight line extending from Point 199, Right Iliospinale Summum to Point 366, Posterior Superior Iliospinale, into four equal segments.

Superior-Most Vertical Lateral Ischio-Iliac Contour Point 507-509: The superior most point of four equidistant points dividing a straight line extending from Point 339, Iliocristale Summum, to Point 405, Superior Tuberosity Point, into five equal segments.

Superior Intermediate Vertical Lateral Ischio-Iliac Contour Point 510-512: The intermediate superior point of four equidistant points dividing a straight line extending from Point 339, Iliocristale Summum, to Point 405, Superior Tuberosity Point, into five equal segments.

Inferior Intermediate Vertical Lateral Ischio-Iliac Contour Point 513-515: The intermediate inferior point of four equidistant points dividing a straight line extending from Point 339, Iliocristale Summum, to Point 405, Superior Tuberosity Point, into five equal segments.

Inferior-Most Intermediate Vertical Lateral Ischio-Iliac Contour Point 516-518: The inferior most point of four equidistant points dividing a straight line extending from Point 339, Iliocristale Summum, to Point 405, Superior Tuberosity Point, into five equal segments.

Acetabulion, Anterior 519-521: The most anteriorly projecting point defined on the pubic portion of the acetabular rim. It is located by rotating the innominate bone on the osteometric board from position 1 to position 2.

Acetabulion, Superior 522-524: The calibration hemisphere is positioned into the acetabulum so that the anterior extremity of one of the diameter lines is opposite Point 519, Acetabulion Anterior. The point is marked on the acetabular rim closest to the superior diameter line when the innominate is oriented in the anatomical position.

Acetabulion, Posterior 525-527: The calibration hemisphere is positioned into the acetabulum so that the anterior extremity of one of the diameter lines is opposite Point 519, Acetabulion Anterior. The point is marked on the acetabular rim closest to the posterior diameter line when the innominate is oriented in the anatomical position.

Acetabulion, Inferior 528-530: The calibration hemisphere is positioned into the acetabulum so that the anterior extremity of one of the diameter lines is opposite Point 519, Acetabulion Anterior. The point is marked on the acetabular rim closest to the inferior diameter line when the innominate is oriented in the anatomical position.

Acetabulion, Center Point 531-533: The calibration hemisphere is positioned into the acetabulum so that the anterior extremity of one of the hemisphere lines is opposite Point 519, Acetabulion Anterior. Insert a marker through the H-point hole and mark the contact point on the interior surface of the acetabulum.

H-Point 534-536: A best-fit plexiglass hemisphere is placed into the acetabulum of the right innominate bone and positioned so that the anterior extremity of one of the perpendicular diameter lines is opposite Point 519, Acetabulum Anterior. H-Point is the center point of the hemisphere surface.

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APPENDIX B

EPOXY MODELS

Small Female | Medium Male | Large Male

Epoxy models of the small female, medium male, and large male pelves. Anterior View.

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Small Female | Medium Male | Large Male

Epoxy models of the small female, medium male, and large male pelves. Lateral View.

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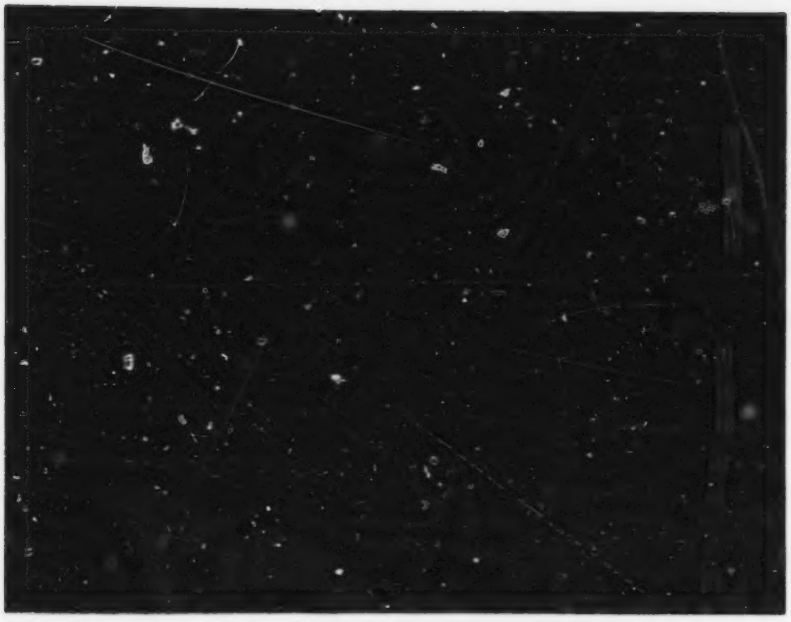

Small Female | Medium Male | Large Male

Epoxy models of the small female, medium male, and large male pelves. Superior View.

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APPENDIX C

THREE-DIMENSIONAL DATA

COORDINATE POINT		COORDINATE POINT VALUES								
		SMALL FEMALE			MEDIUM MALE			LARGE MALE		
NO	AXIS	N	MEAN	SD	N	MEAN	SD	N	MEAN	SD
177	X	27	- 56	11	32	- 59	9	26	- 57	10
178	Y	27	0	3	32	0	5	26	0	4
179	Z	27	18	15	32	12	16	26	16	8
180	X	27	- 6	1	33	9	1	26	- 1	7
181	Y	28	- 5	2	33	- 4	2	26	- 5	2
182	Z	28	- 76	9	33	- 77	9	26	- 78	8
183	X	28	6	10	33	- 9	1	26	2	7
184	Y	28	5	2	33	4	2	26	3	2
185	Z	28	- 76	9	33	- 78	9	26	- 77	9
186	X	28	- 87	9	33	- 96	9	26	-100	8
187	Y	28	- 66	7	33	- 61	7	26	- 62	7
188	Z	28	-102	14	33	-119	11	26	-120	9
189	X	27	- 44	5	33	- 48	6	26	- 50	6
190	Y	28	- 76	25	33	- 82	5	26	- 86	5
191	Z	28	- 47	65	33	- 66	7	26	- 67	7
192	X	28	-120	11	33	-134	9	26	-137	11
193	Y	28	- 40	8	33	- 36	8	26	- 37	7
194	Z	27	34	17	33	31	16	26	35	13
195	X	28	- 40	10	33	- 48	9	26	- 49	9
196	Y	28	-114	11	33	-119	10	26	-125	8
197	Z	28	53	9	33	60	7	26	63	8
198	X	28	0	0	33	0	0	26	0	0
199	Y	28	-109	12	33	-113	9	26	-115	8
200	Z	23	0	0	33	0	0	18	0	0
201	X	28	0	0	33	0	0	25	0	0
202	Y	28	109	12	33	117	8	26	115	8
203	Z	7	0	0	33	0	0	15	0	0
204	X	27	0	0	33	0	0	26	0	0
205	Y	21	0	0	33	0	0	14	0	0
206	Z	28	- 76	9	33	- 78	9	26	- 78	9
207	X	28	- 63	12	33	- 69	9	26	- 68	12
208	Y	28	19	3	33	26	5	26	28	4
209	Z	28	31	15	33	29	15	26	33	8
210	X	27	- 69	10	32	- 83	39	26	- 78	8
211	Y	27	53	5	32	56	5	26	59	5
212	Z	27	21	16	32	28	26	26	27	12
213	X	25	- 79	10	32	- 87	10	24	- 90	10
214	Y	25	38	5	32	44	5	24	46	7
215	Z	25	48	15	32	48	13	24	53	8
216	X	28	- 74	11	33	- 79	14	26	- 81	12
217	Y	28	0	3	33	0	5	26	0	4
218	Z	28	37	14	33	33	14	26	39	8
219	X	28	- 77	12	33	- 85	9	26	- 87	—
220	Y	28	13	4	33	17	5	26	15	13
221	Z	28	47	15	33	44	15	26	38	6
222	X	27	- 82	12	33	- 89	16	26	- 92	13

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COORDINATE POINT		COORDINATE POINT VALUES								
		SMALL FEMALE			MEDIUM MALE			LARGE MALE		
NO	AXIS	N	MEAN	SD	N	MEAN	SD	N	MEAN	SD
223	Y	27	22	4	33	26	6	26	28	5
224	Z	27	52	15	33	48	18	26	56	8
225	X	28	- 83	11	33	- 97	41	26	- 93	11
226	Y	28	14	4	33	17	6	26	18	4
227	Z	28	39	15	33	38	20	26	42	9
228	X	28	- 88	12	33	- 99	10	26	-100	11
229	Y	28	22	4	33	26	6	26	28	4
230	Z	28	44	15	33	40	14	26	45	9
231	X	26	- 79	12	31	- 81	31	26	- 87	12
232	Y	26	13	3	31	17	4	26	16	4
233	Z	26	35	14	31	31	18	26	38	8
234	X	24	- 85	14	31	- 94	15	23	- 95	13
235	Y	24	0	4	31	0	4	23	0	4
236	Z	24	27	15	31	24	15	23	28	8
237	X	25	- 96	13	32	-104	18	23	-107	13
238	Y	25	0	4	32	0	4	23	0	4
239	Z	26	38	16	32	32	15	23	40	9
240	X	20	-109	11	30	-122	10	21	-122	12
241	Y	20	0	4	30	0	4	21	0	4
242	Z	20	36	19	30	35	16	21	40	11
243	X	25	-121	11	29	-134	9	20	-135	10
244	Y	25	0	3	29	0	4	20	0	4
245	Z	25	25	19	29	18	18	20	23	12
246	X	22	-129	10	20	-141	9	21	-145	8
247	Y	22	0	3	20	0	3	21	0	4
248	Z	22	10	19	20	- 2	2	21	3	12
249	X	24	-133	8	30	-139	6	25	-145	6
250	Y	24	0	4	30	0	3	25	0	4
251	Z	24	- 43	20	30	- 60	21	25	- 60	17
252	X	28	-118	10	31	-130	8	25	-139	31
253	Y	28	28	5	31	31	5	24	30	8
254	Z	28	13	17	31	4	13	25	9	40
255	X	27	-134	8	32	-143	7	26	-147	6
256	Y	27	0	3	32	0	4	26	0	3
257	Z	27	- 13	17	32	- 25	21	26	24	18
258	X	STD	REF	POINT	STD	REF	POINT	STD	REF	POINT
259	Y	STD	REF	POINT	STD	REF	POINT	STD	REF	POINT
260	Z	STD	REF	POINT	STD	REF	POINT	STD	REF	POINT
261	X	27	- 76	8	32	- 82	8	26	- 82	7
262	Y	27	- 49	6	32	- 48	6	26	- 50	6
263	Z	27	7	13	32	3	11	26	4	8
264	X	26	- 84	9	33	- 91	8	24	- 92	8
265	Y	26	- 49	6	33	- 48	6	24	- 49	4
266	Z	26	19	14	33	17	12	24	20	9
267	X	26	- 77	10	32	- 84	8	25	- 85	9
268	Y	26	- 53	5	32	- 53	6	25	- 56	6

BEST DOCUMENT AVAILABLE

COORDINATE POINT		COORDINATE POINT VALUES								
		SMALL FEMALE			MEDIUM MALE			LARGE MALE		
NO	AXIS	N	MEAN	SD	N	MEAN	SD	N	MEAN	SD
269	Z	26	32	13	32	31	12	25	35	10
270	X	27	- 69	9	33	- 73	8	26	- 74	7
271	Y	27	- 55	5	33	- 54	6	26	- 56	6
272	Z	27	19	13	33	16	11	26	19	9
273	X	26	- 92	9	33	-100	8	26	-102	10
274	Y	26	- 42	6	33	- 41	6	26	- 43	5
275	Z	26	- 4	14	33	- 12	12	26	- 11	9
276	X	25	-119	33	32	-123	8	25	-125	8
277	Y	25	- 43	5	32	- 42	4	25	- 44	5
278	Z	25	1	24	32	- 12	14	25	- 11	11
279	X	26	- 96	9	32	-106	8	25	-108	10
280	Y	26	- 46	5	32	- 43	5	25	- 44	6
281	Z	26	11	14	32	4	12	25	7	11
282	X	26	- 86	11	33	- 93	8	26	- 96	9
283	Y	26	- 48	6	33	- 47	6	26	- 47	5
284	Z	26	15	15	33	11	12	26	12	10
285	X	28	- 69	9	33	- 75	8	26	- 75	9
286	Y	28	49	6	33	51	5	26	47	20
287	Z	28	2	13	33	- 5	11	26	- 9	7
288	X	28	- 72	10	33	- 77	8	26	- 76	9
289	Y	28	26	4	33	29	4	26	30	5
290	Z	28	15	14	33	9	13	26	12	8
291	X	27	- 69	12	33	- 74	9	26	- 73	10
292	Y	27	0	3	33	0	4	26	0	6
293	Z	27	17	14	33	9	14	26	12	7
294	X	28	- 83	13	32	- 89	10	26	- 87	10
295	Y	28	0	3	32	0	4	26	0	3
296	Z	28	11	15	32	3	13	26	6	7
297	X	28	-105	12	33	-113	8	26	-111	9
298	Y	28	0	3	33	0	3	26	0	3
299	Z	28	1	16	33	- 9	14	26	- 7	9
300	X	28	-113	10	33	-123	6	26	-121	8
301	Y	28	0	3	33	0	3	26	0	3
302	Z	28	- 4	18	33	- 16	15	26	- 13	11
303	X	28	-118	10	33	-126	6	26	-127	7
304	Y	28	0	3	33	0	3	26	0	3
305	Z	28	- 11	17	33	- 23	15	26	- 22	10
306	X	26	-125	7	33	-132	5	26	-135	5
307	Y	26	0	3	33	0	3	26	0	3
308	Z	26	- 28	15	33	- 40	17	26	- 38	12
309	X	9	-124	6	18	-134	6	11	-137	5
310	Y	9	0	2	18	0	3	11	0	4
311	Z	9	- 44	15	18	- 52	18	11	- 58	17
312	X	22	-126	8	32	-132	7	26	-137	9
313	Y	22	0	4	32	0	4	26	0	11
314	Z	22	- 46	17	32	- 63	17	25	- 62	16

BEST DOCUMENT AVAILABLE

COORDINATE POINT		COORDINATE POINT VALUES								
		SMALL FEMALE			MEDIUM MALE			LARGE MALE		
NO	AXIS	N	MEAN	SD	N	MEAN	SD	N	MEAN	SD
315	X	24	-129	9	32	-135	6	25	-140	6
316	Y	24	8	3	32	9	5	25	9	4
317	Z	24	- 43	19	32	- 62	17	26	- 52	52
318	X	22	-125	8	25	-132	6	24	-137	6
319	Y	22	27	3	25	29	9	24	30	6
320	Z	22	- 28	16	25	- 48	18	24	- 45	14
321	X	28	-105	9	31	-118	7	26	-119	8
322	Y	28	42	4	31	44	10	26	44	6
323	Z	28	- 5	14	31	- 18	14	26	- 19	12
324	X	STD	REF	POINT	STD	REF	POINT	STD	REF	POINT
325	Y	STD	REF	POINT	STD	REF	POINT	STD	REF	POINT
326	Z	STD	REF	POINT	STD	REF	POINT	STD	REF	POINT
327	X	28	9	3	33	- 3	3	26	0	3
328	Y	28	106	12	33	112	9	26	110	8
329	Z	28	10	4	33	9	5	26	11	6
330	X	28	- 37	8	33	- 46	7	26	- 48	11
331	Y	28	122	11	33	133	8	26	134	7
332	Z	28	38	8	33	42	10	26	46	9
333	X	28	- 15	4	33	- 20	4	26	- 19	4
334	Y	28	123	12	33	132	9	26	132	8
335	Z	28	27	5	33	30	5	26	33	4
336	X	28	- 12	5	33	- 18	5	26	- 18	5
337	Y	28	114	12	33	123	9	26	122	7
338	Z	28	31	4	33	34	5	26	38	4
339	X	28	- 38	5	33	- 47	9	26	- 49	9
340	Y	28	114	10	33	124	8	26	125	8
341	Z	28	54	9	33	61	8	26	63	8
342	X	28	- 65	10	33	- 77	10	26	- 81	10
343	Y	28	92	9	33	100	7	26	100	8
344	Z	28	65	10	33	74	10	26	78	7
345	X	28	- 61	10	33	- 71	16	26	- 77	12
346	Y	28	89	9	33	95	7	26	91	21
347	Z	28	66	10	33	73	10	26	76	16
348	X	28	- 76	13	33	- 88	12	26	- 91	13
349	Y	28	58	7	33	63	10	26	63	9
350	Z	28	63	14	33	68	13	26	73	9
351	X	28	- 84	11	33	- 98	12	26	-103	12
352	Y	28	64	6	33	66	6	26	66	7
353	Z	28	64	13	33	69	13	26	73	8
354	X	28	- 79	12	33	- 93	11	26	- 97	12
355	Y	28	58	7	33	60	7	26	60	7
356	Z	28	63	13	33	68	12	26	72	8
357	X	27	-109	12	33	-124	11	26	-130	12
358	Y	27	45	5	33	46	6	26	45	6
359	Z	27	47	15	33	46	13	26	49	11
360	X	28	-101	11	33	-114	9	26	-117	12

BEST DOCUMENT AVAILABLE

COORDINATE POINT		COORDINATE POINT VALUES								
		SMALL FEMALE			MEDIUM MALE			LARGE MALE		
NO	AXIS	N	MEAN	SD	N	MEAN	SD	N	MEAN	SD
361	Y	28	38	5	33	38	5	26	38	6
362	Z	28	44	15	33	42	14	26	44	10
363	X	27	-119	11	33	-134	10	26	-139	10
364	Y	27	38	6	33	37	5	26	38	7
365	Z	27	32	17	33	29	16	26	32	11
366	X	28	-118	9	33	-131	8	26	-135	8
367	Y	28	35	4	33	35	4	26	35	5
368	Z	28	17	15	33	11	15	26	12	10
369	X	28	-113	9	33	-126	7	26	-130	8
370	Y	28	43	4	33	44	4	26	44	4
371	Z	28	11	15	33	4	13	26	4	10
372	X	28	-110	9	33	-123	10	26	-128	7
373	Y	28	44	4	33	45	4	26	46	4
374	Z	28	- 6	15	33	- 11	13	26	10	10
375	X	28	- 97	7	33	-111	8	26	-113	7
376	Y	28	52	4	33	52	4	26	55	4
377	Z	28	- 7	14	33	- 17	12	26	- 17	8
378	X	28	- 84	6	33	- 97	7	26	-101	11
379	Y	28	59	5	33	58	4	26	57	15
380	Z	28	- 9	12	33	- 14	11	26	- 16	12
381	X	28	- 74	5	33	- 85	5	26	- 88	5
382	Y	28	66	5	33	66	4	26	67	4
383	Z	28	- 19	10	33	- 21	9	26	- 20	7
384	X	28	- 78	5	33	- 89	4	26	- 91	5
385	Y	28	62	5	33	60	4	26	60	4
386	Z	28	- 39	10	33	- 45	9	26	- 45	7
387	X	STD	REF	POINT	STD	REF	POINT	STD	REF	POINT
388	Y	STD	REF	POINT	STD	REF	POINT	STD	REF	POINT
389	Z	STD	REF	POINT	STD	REF	POINT	STD	REF	POINT
390	X	22	- 88	6	28	- 90	32	22	-106	5
391	Y	22	48	24	28	54	23	22	48	5
392	Z	22	- 55	22	28	- 56	21	22	- 65	8
393	X	27	- 86	6	31	- 96	5	26	-107	37
394	Y	27	60	5	31	54	4	26	55	5
395	Z	27	- 73	12	31	- 86	9	26	- 81	31
396	X	28	- 90	8	33	- 99	6	26	-104	8
397	Y	28	56	6	33	48	5	26	50	8
398	Z	28	- 94	13	33	-111	10	26	-110	8
399	X	28	- 70	10	33	- 76	7	26	- 77	8
400	Y	28	48	5	33	39	5	26	41	7
401	Z	28	-114	11	33	-132	8	26	-136	9
402	X	28	- 73	9	33	- 81	7	26	- 82	8
403	Y	28	71	5	33	67	5	26	71	7
404	Z	28	- 95	11	33	-114	9	26	-112	8
405	X	28	- 80	6	33	- 91	6	26	- 93	6
406	Y	28	74	4	33	72	4	26	74	6

BEST DOCUMENT AVAILABLE

COORDINATE POINT		COORDINATE POINT VALUES								
		SMALL FEMALE			MEDIUM MALE			LARGE MALE		
NO	AXIS	N	MEAN	SD	N	MEAN	SD	N	MEAN	SD
407	Z	28	- 72	11	33	- 85	8	26	- 83	9
408	X	28	- 87	9	33	- 96	7	26	- 99	7
409	Y	28	66	5	33	60	5	26	63	6
410	Z	28	-100	12	33	-118	9	26	-120	9
411	X	28	- 44	6	33	- 45	4	26	- 47	4
412	Y	28	33	3	33	29	3	26	30	3
413	Z	28	- 95	8	33	-106	7	26	-109	7
414	X	28	- 41	7	33	- 41	5	26	- 42	6
415	Y	28	31	3	33	25	4	26	26	4
416	Z	28	-107	9	33	-121	7	26	-123	7
417	X	28	- 48	6	33	- 53	5	26	- 53	5
418	Y	28	53	3	33	50	3	26	52	4
419	Z	28	- 74	9	33	- 84	8	26	- 85	7
420	X	28	- 64	7	33	- 69	5	26	- 71	6
421	Y	28	50	4	33	46	4	26	47	5
422	Z	28	- 94	10	33	-107	8	26	-110	8
423	X	28	- 25	5	33	- 29	4	26	- 30	5
424	Y	28	4	2	33	5	2	26	4	2
425	Z	28	- 95	9	33	-104	8	26	-106	8
426	X	28	- 9	4	33	- 12	45	26	- 10	3
427	Y	28	6	3	33	9	2	26	6	2
428	Z	28	- 89	9	33	- 94	42	26	- 97	8
429	X	28	- 16	3	33	- 21	2	26	- 26	3
430	Y	28	3	2	33	3	2	26	3	2
431	Z	28	- 81	9	33	- 85	8	26	- 81	8
432	X	26	6	4	33	- 5	46	26	2	3
433	Y	26	27	5	33	25	3	26	27	4
434	Z	26	- 75	8	33	- 76	42	26	- 83	8
435	X	28	- 13	4	33	- 13	3	26	- 14	3
436	Y	28	38	4	33	41	3	26	41	4
437	Z	28	- 71	8	33	- 78	7	26	- 79	7
438	X	28	- 11	3	32	- 13	3	26	- 12	3
439	Y	28	34	4	32	33	3	26	34	4
440	Z	28	- 64	8	32	- 68	7	26	- 67	7
441	X	28	- 27	4	33	- 29	3	26	- 29	4
442	Y	28	33	3	33	34	3	26	34	3
443	Z	28	- 73	8	33	- 79	8	26	- 79	6
444	X	28	- 21	4	33	- 21	4	26	- 22	19
445	Y	28	63	6	33	64	5	26	59	3
446	Z	28	- 46	8	33	- 53	7	26	- 66	63
447	X	STD	REF	POINT	STD	REF	POINT	STD	REF	POINT
448	Y	STD	REF	POINT	STD	REF	POINT	STD	REF	POINT
449	Z	STD	REF	POINT	STD	REF	POINT	STD	REF	POINT
450	X	28	- 53	5	33	- 58	5	26	- 60	12
451	Y	28	62	6	33	61	5	26	54	33
452	Z	28	- 24	10	33	- 30	8	26	- 33	25

BEST DOCUMENT AVAILABLE

COORDINATE POINT		COORDINATE POINT VALUES								
		SMALL FEMALE			MEDIUM MALE			LARGE MALE		
NO	AXIS	N	MEAN	SD	N	MEAN	SD	N	MEAN	SD
453	X	28	- 35	4	33	- 39	4	26	- 44	18
454	Y	28	52	5	33	51	4	26	44	31
455	Z	28	- 48	8	33	- 52	7	26	- 55	23
456	X	28	- 22	3	33	- 24	2	26	- 27	9
457	Y	28	31	3	33	32	3	26	26	28
458	Z	28	- 68	8	33	- 73	7	26	- 75	21
459	X	28	- 79	7	33	- 87	4	26	- 90	11
460	Y	28	56	5	33	50	4	26	45	31
461	Z	28	- 77	11	33	- 90	9	26	- 91	18
462	X	28	- 69	5	33	- 76	4	26	- 79	10
463	Y	28	57	4	33	53	3	26	48	32
464	Z	28	- 58	10	33	- 68	9	26	- 70	19
465	X	28	- 60	5	33	- 73	4	26	- 68	11
466	Y	28	61	5	33	59	4	26	52	33
467	Z	28	- 38	10	33	- 42	26	26	- 49	22
468	X	28	- 49	6	33	- 56	5	26	- 59	14
469	Y	28	77	8	33	80	6	26	72	37
470	Z	28	- 1	9	33	- 5	8	26	- 9	3
471	X	28	- 46	7	33	- 55	6	26	- 64	52
472	Y	28	90	9	33	96	7	26	87	41
473	Z	28	17	8	33	15	8	26	12	35
474	X	28	- 42	7	33	- 51	7	26	- 57	19
475	Y	28	101	10	33	109	8	26	99	44
476	Z	28	36	9	33	37	7	26	32	38
477	X	28	- 62	8	33	- 69	9	26	- 74	16
478	Y	28	75	6	33	82	5	26	74	38
479	Z	28	22	11	33	17	9	26	12	32
480	X	26	- 44	6	33	- 49	4	26	- 53	17
481	Y	28	90	8	33	96	6	26	86	41
482	Z	28	13	8	33	10	6	26	4	32
483	X	28	- 21	4	33	- 24	3	26	- 28	16
484	Y	28	99	9	33	105	6	26	93	43
485	Z	28	7	4	33	5	4	25	- 2	34
486	X	28	- 12	3	33	- 15	3	26	- 19	15
487	Y	28	98	8	33	104	6	26	95	43
488	Z	28	- 9	4	33	- 12	4	26	- 18	30
489	X	28	- 14	5	33	- 16	5	26	- 18	13
490	Y	28	90	6	33	95	4	26	87	42
491	Z	28	- 27	6	33	- 33	6	26	- 36	27
492	X	28	- 24	5	33	- 25	4	26	- 29	12
493	Y	28	84	5	33	87	5	26	80	40
494	Z	28	- 39	6	33	- 45	7	26	- 49	24
495	X	STD	REF	POINT	STD	REF	POINT	STD	REF	POINT
496	Y	STD	REF	POINT	STD	REF	POINT	STD	REF	POINT
497	Z	STD	REF	POINT	STD	REF	POINT	STD	REF	POINT
498	X	28	- 35	4	33	- 40	3	26	- 45	15

BEST DOCUMENT AVAILABLE

COORDINATE POINT		COORDINATE POINT VALUES								
		SMALL FEMALE			MEDIUM MALE			LARGE MALE		
NO	AXIS	N	MEAN	SD	N	MEAN	SD	N	MEAN	SD
499	Y	28	101	8	33	108	6	26	99	44
500	Z	28	4	5	33	1	4	26	- 5	31
501	X	28	- 63	6	33	- 70	5	26	- 86	14
502	Y	28	78	6	33	89	5	26	77	38
503	Z	28	10	8	33	5	7	26	3	30
504	X	28	- 95	8	33	-103	14	26	-112	14
505	Y	28	60	5	33	63	4	26	56	34
506	Z	28	16	13	33	7	12	25	5	29
507	X	28	- 45	6	33	- 57	7	26	- 62	17
508	Y	28	102	9	33	110	7	26	101	45
509	Z	28	26	9	33	27	6	26	22	36
510	X	28	- 50	5	33	- 60	5	26	- 65	14
511	Y	28	90	8	33	95	6	26	88	41
512	Z	28	1	9	33	- 1	6	26	- 5	30
513	X	28	- 60	5	33	- 71	4	26	- 84	56
514	Y	28	84	7	33	87	5	26	81	38
515	Z	28	- 24	9	33	- 30	7	26	- 28	8
516	X	28	- 72	5	33	- 84	5	26	- 96	53
517	Y	28	80	6	33	81	5	26	76	36
518	Z	28	- 48	10	33	- 58	8	26	- 54	9
519	X	28	- 24	5	33	- 24	4	26	- 31	23
520	Y	28	66	4	33	68	4	26	62	36
521	Z	28	- 63	8	33	- 71	7	26	- 75	21
522	X	28	- 31	5	33	- 34	5	26	- 39	11
523	Y	28	91	5	33	98	5	26	90	42
524	Z	28	- 40	7	33	- 44	6	26	- 48	24
525	X	28	- 63	6	33	- 73	5	26	- 77	10
526	Y	28	90	5	33	94	6	26	87	41
527	Z	28	- 51	8	33	- 57	8	26	- 60	20
528	X	28	- 54	6	33	- 61	5	26	- 64	10
529	Y	28	71	5	33	73	5	26	67	37
530	Z	28	- 77	9	33	- 88	7	26	- 90	18
531	X	28	- 51	4	33	- 56	4	26	- 60	11
532	Y	28	62	5	33	62	6	26	56	34
533	Z	28	- 44	9	33	- 50	8	26	- 53	22
534	X	27	- 43	5	33	- 48	5	26	- 52	10
535	Y	27	81	4	33	83	5	26	78	39
536	Z	27	- 59	7	33	- 65	7	26	- 69	20
537	X	27	- 76	7	32	- 82	9	26	- 81	7
538	Y	27	- 47	6	32	- 45	6	26	- 46	6
539	Z	27	- 1	13	32	- 8	11	26	- 6	8
540	X	28	- 51	5	33	- 55	6	26	- 58	13
541	Y	28	63	6	33	63	5	26	55	34
542	Z	28	- 19	9	33	- 24	9	26	- 28	26
543	X	28	- 47	6	33	- 49	5	26	- 51	5
544	Y	28	28	4	33	21	4	26	21	4
545	Z	28	- 98	9	33	-114	8	26	-115	8

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